WHAT IS CLAIMED IS:

1. A method of adjusting a projection optical apparatus that projects an image of an object which is arranged in a first surface onto a second surface, comprising:

a first step of measuring an aberration of the projection optical apparatus having a plurality of optical elements and at least one correction element;

a second step of calculating, based on a measurement result of the first step, a surface shape that the correction element should have, the aberration of the projection optical apparatus being a predetermined value when the correction element has the surface shape that the correction element should have;

a third step of removing the correction element from the projection optical apparatus and machining the correction element so that the surface shape of the correction element coincides with the surface shape calculated in the second step; and

a fourth step of returning the correction element machined in the third step into the projection optical apparatus.

2. A method according to claim 1, further comprising a fifth step of correcting components of various aberrations of the projection optical apparatus that are symmetric with respect to an optical axis of the projection optical apparatus.

3. A method according to claim 1, further comprising a fifth step of measuring components of various aberrations of the projection optical apparatus that are symmetric with respect to an optical axis of the projection optical apparatus.

4. A method according to claim 3, further comprising a sixth step of correcting the components of various aberrations of the projection optical apparatus that are symmetric with respect to the optical axis of the projection optical apparatus.

5. A method according to claim 3, wherein the fifth step is executed prior to the first step.

6. A method according to claim 3, wherein the aberration measured in the first step includes a random component.

7. A method according to claim 1, wherein the correction element is arranged at a most first surface side of the projection optical apparatus.

8. A method according to claim 7, wherein the correction element is a plane-parallel plate.

9. A method according to claim 1, wherein the correction element arranged in the first step is a dummy element and is different from the correction element machined in the third step.

10. A method according to claim 1, wherein the correction element in the first step has a predetermined refracting power.

11. A method of manufacturing a projection optical apparatus comprising the steps of:

preparing the projection optical apparatus; and

adjusting the projection optical apparatus by a method according to claim 1.

12. A projection optical apparatus manufactured by a method according to claim 11.

13. An exposure apparatus comprising:

an illumination apparatus;

the projection optical apparatus adjusted in accordance with a method according to claim 1;

a first stage, arranged between the illumination apparatus and the projection optical apparatus, for holding a mask on a position of the first surface; and

a second stage for holding a photosensitive substrate on a position of the second surface.

14. A method of manufacturing a circuit pattern, using an exposure apparatus according to claim 13, the method comprising the step of printing the circuit pattern on the mask onto the photosensitive substrate.

15. A method of adjusting a projection optical apparatus that projects an image of an object which is arranged in a first surface onto a second surface, comprising:

a first step of measuring an aberration of the projection optical apparatus having a plurality of optical elements and at least one correction element; and

a second step of correcting, based on a measurement result of the first step, the aberration of the projection optical apparatus to a predetermined value;

wherein the second step comprises a first sub-step of obtaining a correction shape with respect to an optical surface of the correction element, a second sub-step of machining the optical surface so that the optical surface has the correction

shape, a third sub-step of coating a film on the optical surface, and a fourth sub-step of placing the optical surface at an optical path of the projection optical system.

16. A method according to claim 15, wherein the film on the optical surface includes an anti-reflection film.

17. A method according to claim 15, wherein the correction element in the first step is a dummy element and is different from the correction element machined in the second sub-step.

18. A method according to claim 15, wherein the correction element is a plane-parallel plate.

19. A method according to claim 15, wherein the correction element in the first step has a predetermined refracting power.

20. A method of manufacturing a projection optical apparatus comprising the steps of:

preparing the projection optical apparatus; and

adjusting the projection optical apparatus by a method according to claim 15.

21. A projection optical apparatus manufactured by a method according to claim 20.

22. An exposure apparatus comprising:

an illumination apparatus;

the projection optical apparatus adjusted in accordance with a method according to claim 15;

a first stage, arranged between the illumination apparatus and the projection optical apparatus, for holding a mask on a position of the first surface; and

a second stage for holding a photosensitive substrate on a position of the second surface.

23. A method of manufacturing a circuit pattern, using an exposure apparatus according to claim 22, the method comprising the step of printing the circuit pattern on the mask onto the photosensitive substrate.

24. A method of adjusting a projection optical apparatus that projects an image of an object which is arranged in a first surface onto a second surface, and that has a plurality of optical elements and at least one correction element, comprising:

a first step of adjusting a position of at least one of the optical elements; and

a second step of correcting an aberration of the projection optical apparatus to a predetermined value;

wherein the second step comprises a first sub-step of obtaining a correction shape with respect to an optical surface of the correction element, a second sub-step of machining the optical surface so that the optical surface has the correction shape, and a third sub-step of placing the optical surface at an optical path of the projection optical apparatus.

25. A method according to claim 24, wherein the first step comprises a sub-step of adjusting a distance between the optical elements.

26. A method according to claim 25, wherein the first step comprises a sub-step of adjusting tilt shift of the optical elements.

27. A method according to claim 24, further comprising:

a third step of measuring an aberration of the projection optical apparatus having the plurality of optical elements and the correction element;

wherein the correcting the aberration of the projection optical system is performed based on a measurement result of the third step.

28. A method of manufacturing a projection optical apparatus comprising the steps of:

preparing the projection optical apparatus; and

adjusting the projection optical apparatus by a method according to claim 24.

29. A projection optical apparatus manufactured by a method according to claim 28.

30. An exposure apparatus comprising:

an illumination apparatus;

the projection optical apparatus adjusted in accordance with a method according to claim 24;

a first stage, arranged between the illumination apparatus and the projection optical apparatus, for holding a mask on a position of the first surface; and

a second stage for holding a photosensitive substrate on a position of the second surface.

31. A method of manufacturing a circuit pattern using an exposure apparatus according to claim 30, the method comprising the step of printing the circuit pattern on the mask onto the photosensitive substrate.

32. A method of manufacturing a projection optical apparatus comprising:

preparing the projection optical apparatus having a plurality of optical elements and at least one correction element;

measuring an aberration of the projection optical apparatus based on a radiation passed through the plurality of optical elements and the at least one correction element;

removing the correction element from the projection optical apparatus;

calculating a surface shape of the correction element based on a measurement result of the measuring step;

machining the correction element based on a calculation result of the calculating step; and

returning the correction element machined in the machining step into the projection optical apparatus.

33. A method according to claim 32, wherein the surface shape of the correction element calculated in the calculating step has a free aspherical shape.

34. A method according to claim 33, wherein the free aspherical shape has a random component.

35. A projection optical apparatus manufactured in accordance with a method according to claim 33.

36. A method of adjusting an optical apparatus that guides a radiation from a first surface to a second surface, comprising:

a first step of measuring an aberration of the optical apparatus having a plurality of optical elements and at least one correction element;

a second step of calculating, based on a measurement result of the first step, a surface shape that the correction element should have, the aberration of the optical apparatus being a predetermined value when the correction element has the surface shape that the correction element should have;

a third step of removing the correction element from the optical apparatus and machining the correction element so that the surface shape of the correction element coincides with the surface shape calculated in the second step; and

a fourth step of returning the correction element machined in the third step into the optical apparatus.

37. A method according to claim 36, further comprising a fifth step of correcting components of various aberrations of the optical apparatus that are symmetric with respect to an optical axis of the optical apparatus.

38. A method according to claim 36, further comprising a fifth step of measuring components of various aberrations of the optical apparatus that are symmetric with respect to an optical axis of the optical apparatus.

39. A method according to claim 38, further comprising a sixth step of correcting the components of various aberrations of the optical apparatus that are symmetric with respect to the optical axis of the optical apparatus.

40. A method according to claim 36, wherein the correction element arranged in the first step is a dummy element and is different from the correction element machined in the third step.

41. A method of manufacturing an optical apparatus comprising the steps of:

preparing the optical apparatus; and

adjusting the optical apparatus by a method according to claim 36.

42. An optical apparatus manufactured by a method according to claim 41.

43. A method of adjusting an optical apparatus that guides a radiation from a first surface to a second surface, comprising:

a first step of measuring an aberration of the optical apparatus having a plurality of optical elements and at least one correction element; and

a second step of correcting, based on a measurement result of the first step, the aberration of the optical apparatus to a predetermined value;

wherein the second step comprises a first sub-step of obtaining a correction shape with respect to an optical surface of the correction element, a second sub-step of machining the optical surface so that the optical surface has the correction shape, a third sub-step of coating a film on the optical surface, and a fourth sub-step of placing the optical surface at an optical path of the optical system.

44. A method of manufacturing an optical apparatus comprising the steps of:

preparing the optical apparatus; and

adjusting the optical apparatus by a method according to claim 43.

45. An optical apparatus manufactured by a method according to claim 44.

46. A method of adjusting an optical apparatus that guides a radiation from a first surface to a second surface, and that has a plurality of optical elements and at least one correction element, comprising:

a first step of adjusting a position of at least one of the optical elements; and

a second step of correcting an aberration of the optical apparatus to a predetermined value;

wherein the second step comprises a first sub-step of obtaining a correction shape with respect to an optical surface of the correction element, a second sub-step of machining the optical surface so that the optical surface has the correction shape, and a third sub-step of placing the optical surface at an optical path of the optical apparatus.

47. A method of manufacturing an optical apparatus comprising the steps of:

preparing the optical apparatus; and

adjusting the optical apparatus by a method according to claim 46.

48. An optical apparatus manufactured by a method according to claim 47.

49. A method of manufacturing an optical apparatus for guiding a radiation from a first surface to a second surface, comprising:

preparing the optical apparatus having a plurality of optical elements and at least one correction element;

measuring an aberration of the optical apparatus based on a radiation passed through the plurality of optical elements and the at least one correction element;

removing the correction element from the optical apparatus;

calculating a surface shape of the correction element based on a measurement result of the measuring step;

machining the correction element based on a calculation result of the calculating step; and

returning the correction element machined in the machining step into the optical apparatus.

50. An optical apparatus manufactured in accordance with a method according to claim 49.